Miami Air International
Jacksonville, Florida
May 3, 2019
DCA19MA143

NATIONAL TRANSPORATION SAFETY BOARD
WASHINGTON, D.C.

ATTACHMENT 6

MIAMI AIRLINES, B737-81Q, EMERGENCY EVACUATION IN RIVER, FWD RH & LH DOOR SLIDE UNSUCCESSFUL DEPLOYMENT

Pages 32

Field Investigation Report

SUBJECT: Miami Air International, B737-81Q, Emergency Evacuation in River, FWD RH & LH Door Slide Unsuccessful Deployment

Report Date: 30-Aug-2019

CUSTOMER	AIRCRAFT	DOOR LOCATION	INCIDENT DATE	INCIDENT LOCATION
Miami Air International (MAI)	B737-81Q, N732MA, MSN 30618	Forward Right Hand Forward Left Hand	03-May-2019	Jacksonville Naval Air Station, Florida

ESCAPE SLIDE P/N	ESCAPE SLIDE S/N (DOM)	SLIDE DESCRIPTION	LAST OVERHAUL
5A3307-7	BNG2562 (Feb-2001) BNG2056 (Sep-2000)	FWD & AFT Door Evacuation Slide, LH/RH	American Southeast Inflatable & Oxygen

1. Description of Incident

On May 3rd 2019, Miami Air International (MAI) aircraft B737-81Q (MSN 30618, Registration N732MA) departed the end of the runway and came to rest in the shallow water of the St. Johns River as it landed at Jacksonville Naval Air Station, Jacksonville, Florida. Flight attendants proceeded with the emergency evacuation procedure and deployed the forward right-hand (FWD RH) door emergency evacuation slide (P/N 5A3307-7, S/N BNG2562), and the forward left-hand (FWD LH) door emergency evacuation slide (P/N 5A3307-7, S/N BNG2056), see Figure 1. The FWD RH slide immediately deflated after the deployment (refer to Figure 2A and 2B), and the FWD LH slide deployed in a twisted orientation (refer to Figure 3A and 3B). Flight attendants at the aft of the aircraft noticed water on the floor and determined it would be unsafe to open the aft doors during a water-landing. The passengers including the crew evacuated safely via the overwing exits.

This incident investigation is led by the NTSB. Under NTSB supervision both FWD slides were removed from the aircraft and shipped to Collins Aerospace in Phoenix, AZ, for further inspection and evaluation.

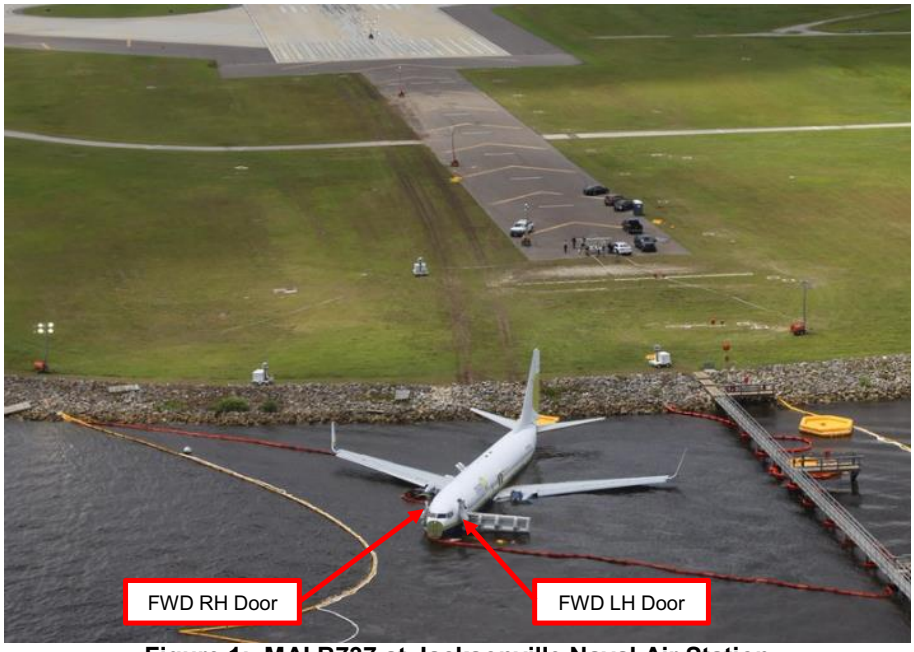

Figure 1: MAI B737 at Jacksonville Naval Air Station
(Photo extracted from CBS news video report)

Figure 2A

Figure 2B

Figure 2A and 2B: FWD RH door emergency evacuation slide in deflated condition
(Photo provided by NTSB)

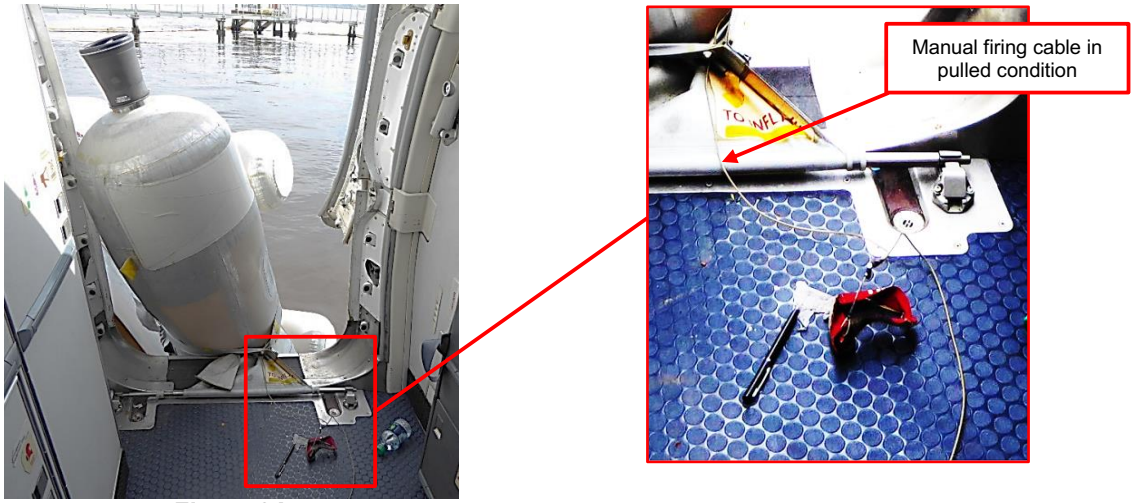

Figure 3A

Figure 3B

Figure 3A and 3B: FWD LH door emergency evacuation slide deployed in twisted orientation
(Photo provided by NTSB)

References

Ref./1/: Miami Air International B737-81Q, N732MA
Ref./2/: Evacuation Slide (GA, FWD RH) P/N 5A3307-7, S/N BNG2562
Ref./3/: Evacuation Slide (GA, FWD LH) P/N 5A3307-7, S/N BNG2056
Ref./4/: CMM 25-60-37 Vol.1 Rev. 10
Ref./5/: CMM 25-60-37 Vol.2 Rev. 02 (Packing Instructions, PI)

2. Background Information

A. Escape Slide Components:

	Part Name	As Received		As Manufactured	
		P/N	S/N	P/N	S/N
FWD RH Dr Slide	737 Escape Slide	5A3307-7	BNG2562	5A3307-3	BNG2562
	Inflatable Assembly	5A3305-101	BNG2562	5A3305-101	BFG2562
FWD LH Dr Slide	737 Escape Slide	5A3307-7	BNG2056	5A3307-3	BNG2056
	Inflatable Assembly	5A3305-101	BNG2056	5A3305-101	BNG2056

Table 1: Slide Components Particulars

B. Recent Overhaul History:

	Inspection/ OVHL Date	OVHL Location	Incoming P/N	Outgoing P/N	Tasks Performed	Disposition	Comments
FWD RH Door Slide (S/N BNG2562)	Jan-2019	American Southeast Inflatable & Oxygen	5A3307-7	5A3307-7	OVHL	Certified for in-service	OVERHAUL
	Feb-2018		5A3307-7	5A3307-7	OVHL	Certified for in-service	OVERHAUL
FWD LH Door Slide (S/N BNG2056)	Jun-2018	American Southeast Inflatable & Oxygen	5A3307-7	5A3307-7	OVHL	Certified for in-service	OVERHAUL
	Jun-2017		5A3307-7	5A3307-7	OVHL	Certified for in-service	OVERHAUL

Table 2: Recent Overhaul History

Maintenance History

The evacuation system P/N 5A3307-7, S/N BNG2562 was manufactured in February 2001 as evacuation system P/N 5A3307-3, S/N BNG2562. American Southeast Inflatable & Oxygen performed the last maintenance on January 2019.

The evacuation system P/N 5A3307-7, S/N BNG2056 was manufactured in September 2000 as evacuation system P/N 5A3307-3, S/N BNG2056. American Southeast Inflatable & Oxygen performed the last maintenance on June 2018.

3. Examination/Investigation

A. Investigation at Collins Aerospace in Phoenix

After the incident, the evacuation slides were sent to Collins Phoenix MRO for an investigation. The investigation team consisted of the following members:

Team members:

Emily Gibson Chaklos	NTSB - Survival Factors Investigator
Albert P. Nixon	NTSB - Regional Investigator
Peggy Jean Hurlbert	FAA - CSI
Bruce Wallace	Boeing - Evacuation Systems Engineering
Eric Folland	Collins Aerospace - Evac Systems Engineering Supervisor
Bruce Friedrich	Collins Aerospace - Evac Systems Sr. Project Engineer
Pradeep Kurian	Collins Aerospace - Evac Systems Product Support Engineer
AL Bale	Collins Aerospace - Evac System Product Safety Engineer
Nelson Gutierrez	Collins Aerospace - Evac System Trainer

B. Slide Inspection

A. FWD RH Door Slide (S/N BNG2562)

The slide assembly received at Collins MRO facility in deployed condition (refer Figure 4).

Figure 4: FWD RH door slide receiving condition
(Picture was taken at Collins Phoenix facility)

Inspection revealed the following issues with the slide:

(a) The secondary restraint (P/N 4A3613-210, 210 lb. shear pin restraint) was not connected (refer to Figure 5A, 5B, and 5C). This secondary restraint should be installed as shown in figure 5D (see instruction (4) on page 7052 and figure 7041 on the page 7053 of CMM 25-60-37 Vol.2). When correctly installed, the restraint separates into two pieces during the slide deployment. Figure 5B shows the restraint at that anchor point and no portion of the restraint shown in anchor point inside the restraint pad, see Figure 5C. This evidence indicates that the restraint was not installed at the anchor point inside the restraint pad and would not result in the restraint breaking as intended during a deployment. Properly installed restraints allow the inflatable sections to inflate sequentially and deploy in a controlled manner.

(b) A 59-inch long tear along the right-hand side inflatable tube was found (refer to Figure 6A and 6B). Tear existed in between the anchor point of the geometric restraint (refer to Figure 6C) and the bulkhead (refer to Figure 6D).

(c) A hole was found on the right-hand side inflatable tube (refer to Figure 7A and 7B).

(d) Left-hand (LH) side truss strap is completely detached from the head end of the slide (refer to Figure 8). Right-hand (RH) side truss strap attachment point is partially detached from the head end of the slide (refer to Figure 9). During the investigation, Boeing presented photographs of the slide removal from the aircraft showing the slide truss strap being used to move the slide. This handling could have caused the truss strap to become detached from the attachment points.

(e) Girt release cable incorrectly routed under Velcro truss tab (refer to Figure 10).

(f) Battery harness was not properly tucked in (refer to Figure 11).

(g) Slide log card last overhaul entry (dated 1-16-19) is not validated with a quality stamp or technician initial (refer to Figure 12). It is expected that a technician initial and a quality stamp should be present in order to confirm the proper overhaul procedures were performed.

NTSB provided forward cabin flight attendant testimonial states that the slide contacted sharp rocks and deflated after deployment. The NTSB field investigation team was not able to confirm the presence of any foreign object that could have caused the damage.

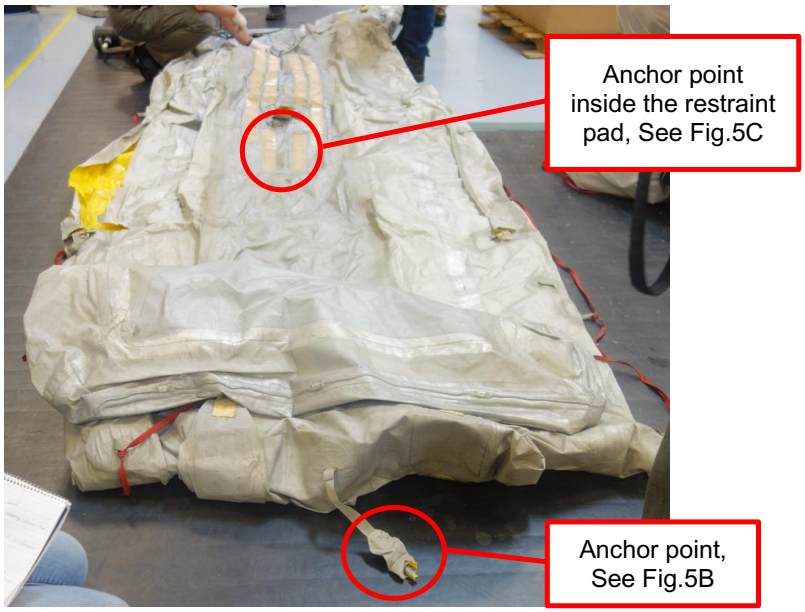

Figure 5A: Secondary restraint improperly installed
(Picture was taken at Collins Phoenix facility)

Figure 5B: Compete restraint at anchor point
(Picture was taken at Collins Phoenix facility)

Figure 5C: Anchor point inside restraint pad
(Picture was taken at Collins Phoenix facility)

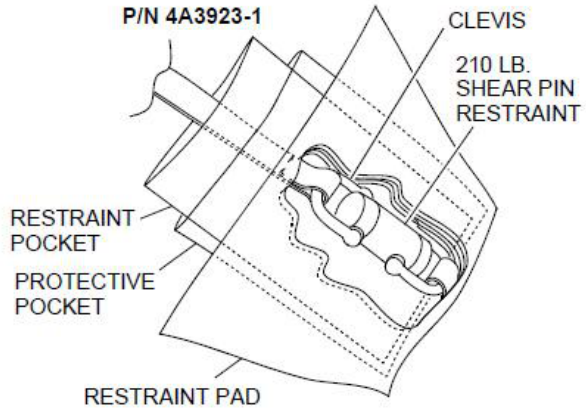

Figure 5D: Secondary restraint properly installed
(Figure 7041 on page 7053 of CMM 25-60-37 Vol.2)

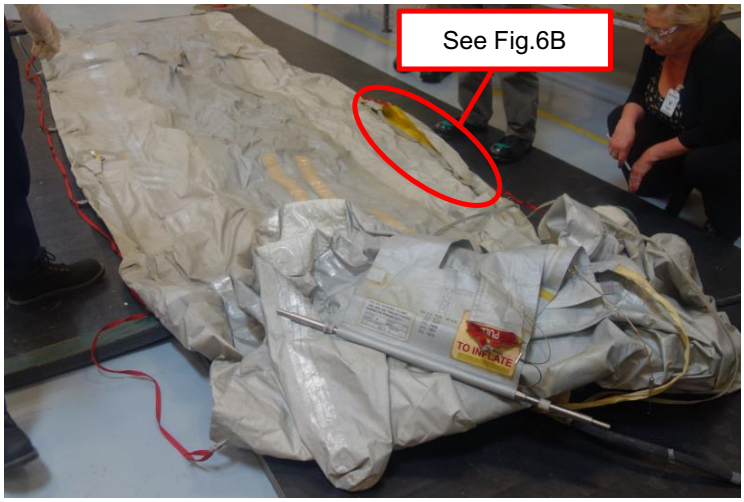

Figure 6A: Tear on right-hand side inflatable tube
(Picture was taken at Collins Phoenix facility)

Figure 6B: Tear between geometric restraint anchor point and bulkhead
(Picture was taken at Collins Phoenix facility)

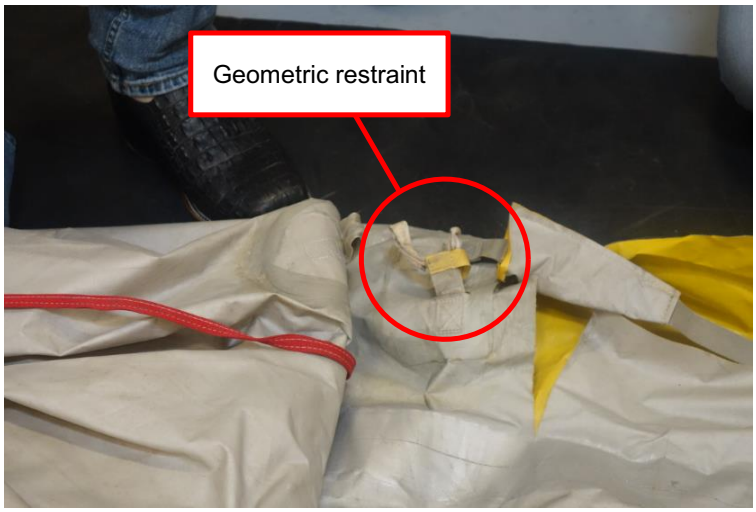

Figure 6C: Tear between geometric restraint anchor point and bulkhead
(Picture was taken at Collins Phoenix facility)

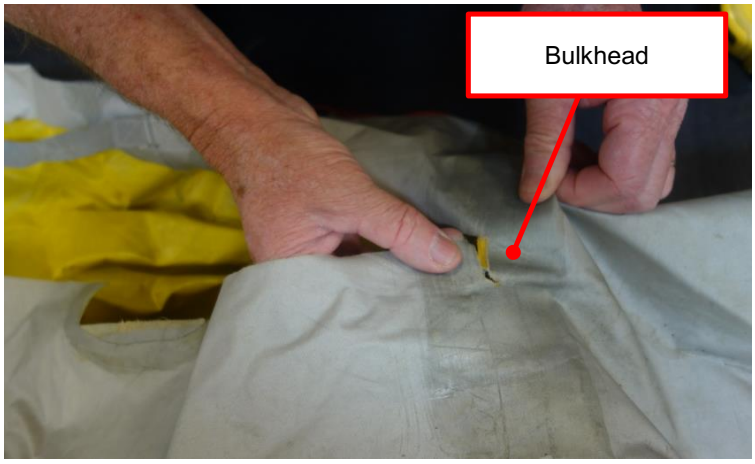

Figure 6D: Tear between geometric restraint anchor point and bulkhead
(Picture was taken at Collins Phoenix facility)

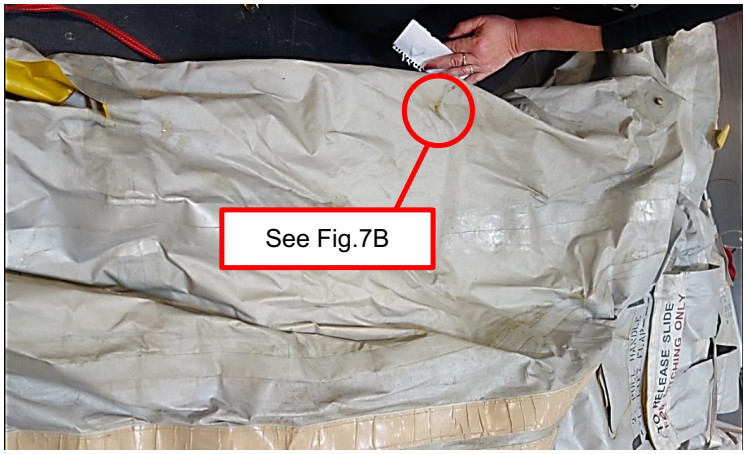

Figure 7A: Thru-hole right-hand side inflatable tube
(Picture was taken at Collins Phoenix facility)

Figure 7B: Hole on right-hand side inflatable tube
(Picture was taken at Collins Phoenix facility)

Figure 8: LH side truss strap completely detached from head end of slide
(Picture was taken at Collins Phoenix facility)

Figure 9: RH side truss strap partially detached from head end of slide
(Picture was taken at Collins Phoenix facility)

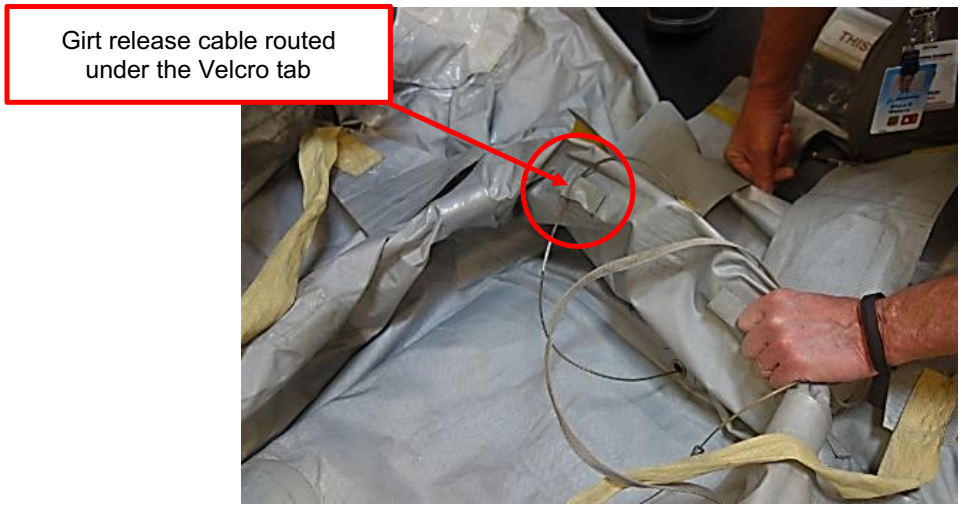

Figure 10: Girt release cable incorrectly routed
(Picture was taken at Collins Phoenix facility)

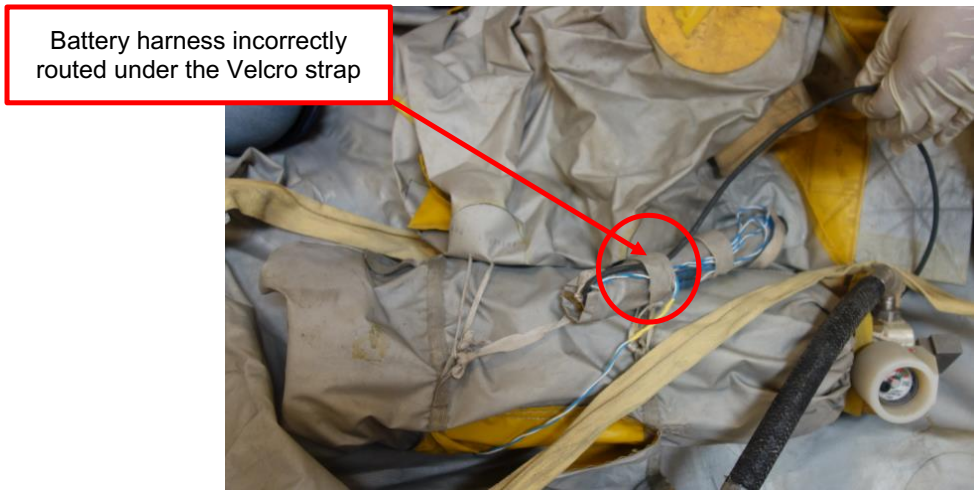

Figure 11: Battery harness (black cable) incorrectly tucked in
(Picture was taken at Collins Phoenix facility)

Goodrich

CN 32B Rev. F

EVACUATION SLIDE INSPECTION/ INVENTORY LOG

Approval: Bob Starr

System (w/Component):

Boeing P/N _____ Goodrich P/N _____ Rev. _____

Slide Assy: Boeing P/N 10-61323-2004 Goodrich P/N 5A3307-7 Rev. —

S/N BNG 2562. Mfg. Date 02/2001 Date Packed 02/07/18 (ASI 6) 01/16/19

Charged Cylinder Assy. P/N 4A3904-5 Rev. —

Valve P/N 4A4047-6 S/N N-1302 Rev. K

Cylinder P/N 630124-04 S/N FZ302577

DOM 01-2014. Hydro Test Date 01-2018 (ASI 6) 01-2019

EXP 01-2029.

Aspirator P/N 5A3265-2 S/N N-2139 Rev. —

PRV P/N 4A3641-25 S/N N9002 Rev. —

Light Battery P/N 7-1045-201 Lot # 9472 0604 5059 / 00814 (ASI 6) Mfg Date 01-19 (ASI 6) Exp Date 01-2024 3/19 (ASI 6)

Acceptable Current Specified Range 70/320mA Pre-Pack Current .346 Post-Pack Current .348

Specified Acceptable Load Voltage 7.0 Volc Actual Voltage 7.33V (ASI 6) 7.73V

Inspected By / Date [redacted] 02/01/2018 (ASI 6) [redacted] 01/16/19

THIS SLIDE ASSEMBLY SHALL BE OPERATED AND MAINTAINED IN ACCORDANCE WITH THE LASTED REVISION OF COMPPONENT MAINTENANCE MANUAL NO. 25-60-37

DATE	OPERATION	INSP. BY
2/1/2018.	overhauled IAW UTC cmm 25-60 33 rev#8.	[redacted]
	next inspection due 02/2019.	
1-16-19	Overhauled IAW UTC cmm 25-60 37 rev# 8.	
	Next inspection due 01/2020.	

3/24/2003

Figure 12: Slide S/N BNG2562 log card

This slide utilizes a Pressure Relief Valve (PRV) to regulate the air pressure during inflatable inflation. Slide inflatable structure could be at risk if the PRV did not function properly. The subject slide PRV was removed and installed on a Collins supplied slide for PRV function testing. The PRV function test was performed per CMM 25-60-37 Vol.1 (reference “Pressure Relief Valve Test” on page 1009). According to the testing requirement, the PRV should open up before pressure reaches 3.2 psig (max.); during testing the PRV opened at 3.18 psig (refer to Figure 13). The PRV should also close before the pressure drops below 2.7 psig (min.), during testing the PRV closed at 2.73 psig (refer to Figure 14). This testing concludes that the subject slide PRV is functioning properly.

Figure 13: Subject slide PRV opened up at 3.18 psig during testing
(Picture was taken at Collins Phoenix facility)

Figure 14: Subject slide PRV closed at 2.73 psig during testing
(Picture was taken at Collins Phoenix facility)

B. FWD LH Door Slide (S/N BNG2056)

The slide assembly received at Collins MRO facility in deployed condition (refer Figure 15), and the girt was detached from the slide (refer Figure 16)

Figure 15: FWD LH door slide receiving condition
(Picture was taken at Collins Phoenix facility)

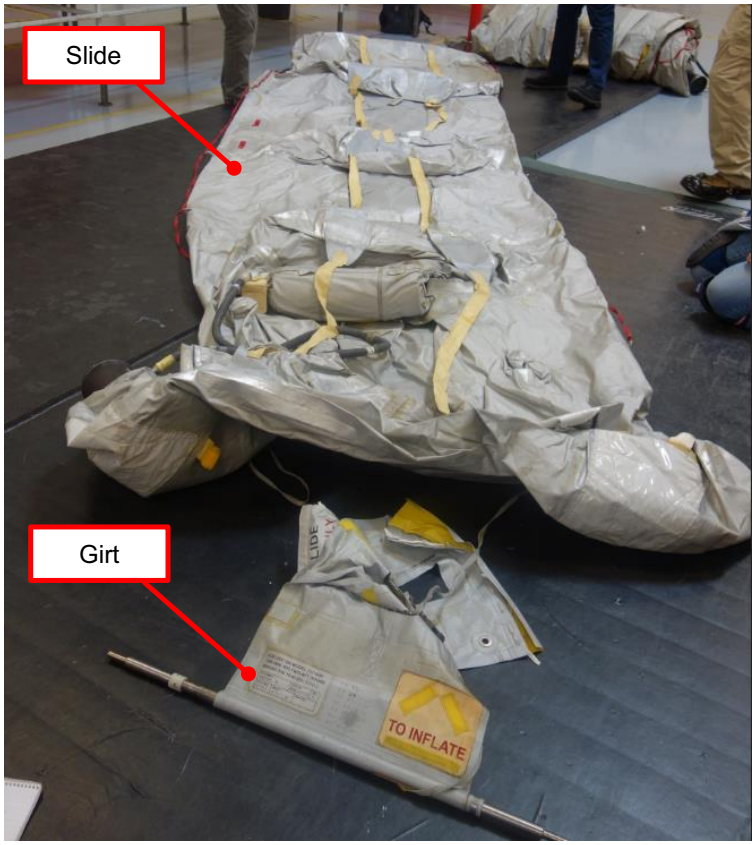

Figure 16: Girt was detached from the slide
(Picture was taken at Collins Phoenix facility)

Inspection revealed the following issues with the slide:

a) The girt was twisted and heavily wrinkled (refer to Figure 17A and 17B). Post-deployment photo (refer to 3A and 3B) shows the girt being twisted due to the improper slide orientation, and per NTSB provided information, the slide remained in this condition until it was removed from the aircraft on May 6th, 2019, which was 3 days after the incident. Twist and heavy wrinkles on the girt are most likely caused by the way it was held in position after post-deployment.

b) Multiple patch repairs were performed on the inflatable seam (refer to Figure 18A, 18B, 19A, and 19B). Per CMM 25-60-37 Vol.1 (reference 4) "Repair Limitations" section (section 3.A.(4) and (5) on page 6005), patch repairs are not allowed on the inflatable seams, holes and tears which extend into seams or through seams, or which come closer than 2 inches to a seam are classified as major defects thus patch repair is not permissible. Therefore, CMM directs users to contact Collins for disposition instructions.

   Inflatable fabric repaired areas should also be covered with the aluminum coating (heat reflective paint). However, these identified patches did not have the required aluminum coating.

Figure 17A: Girt was twisted and wrinkled heavily
(Picture was taken at Collins Phoenix facility)

Figure 17B: Girt was twisted and wrinkled heavily
(Picture was taken at Collins Phoenix facility)

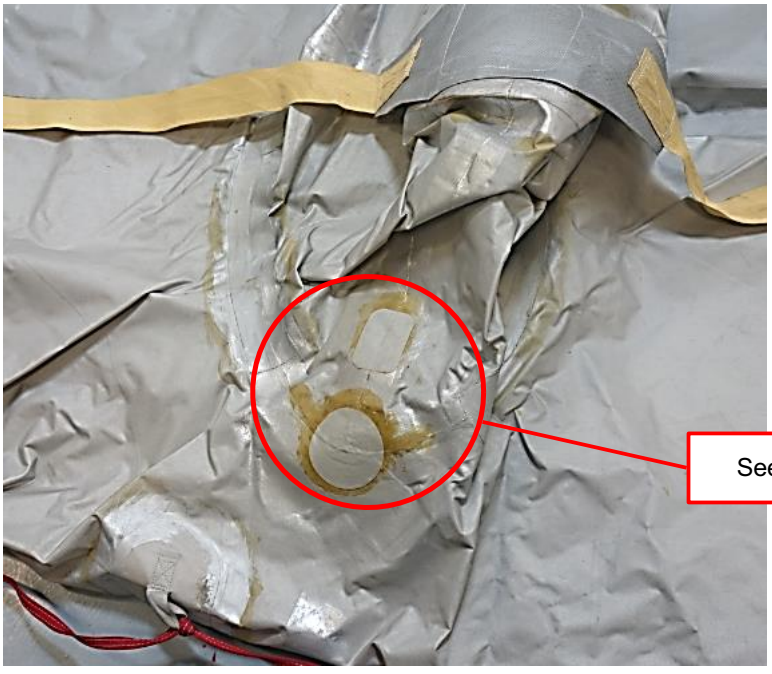

Figure 18A: Patches over seam and no heat reflective paint applied
(Picture was taken at Collins Phoenix facility)

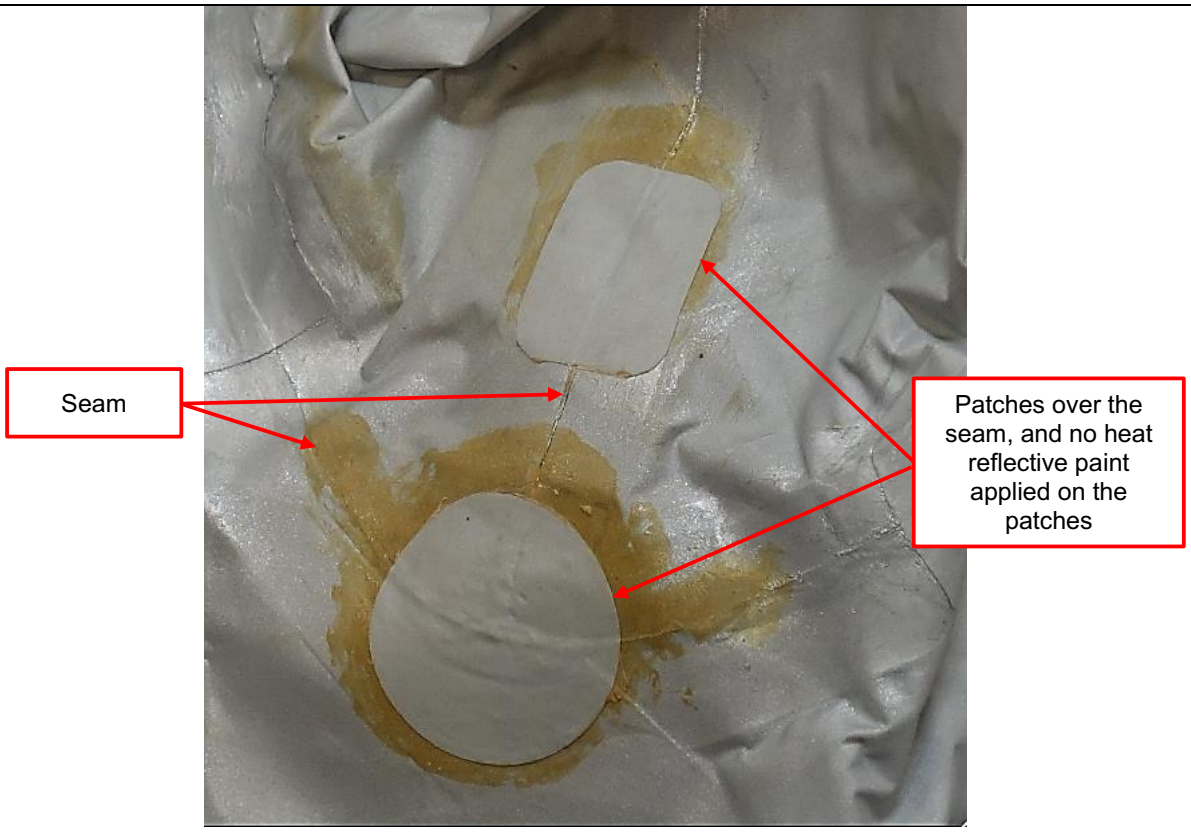

Figure 18B: Patches over the seam no heat reflective paint applied
(Picture was taken at Collins Phoenix facility)

Figure 19A: Patches overlapping seam and no heat reflective paint is applied
(Picture was taken at Collins Phoenix facility)

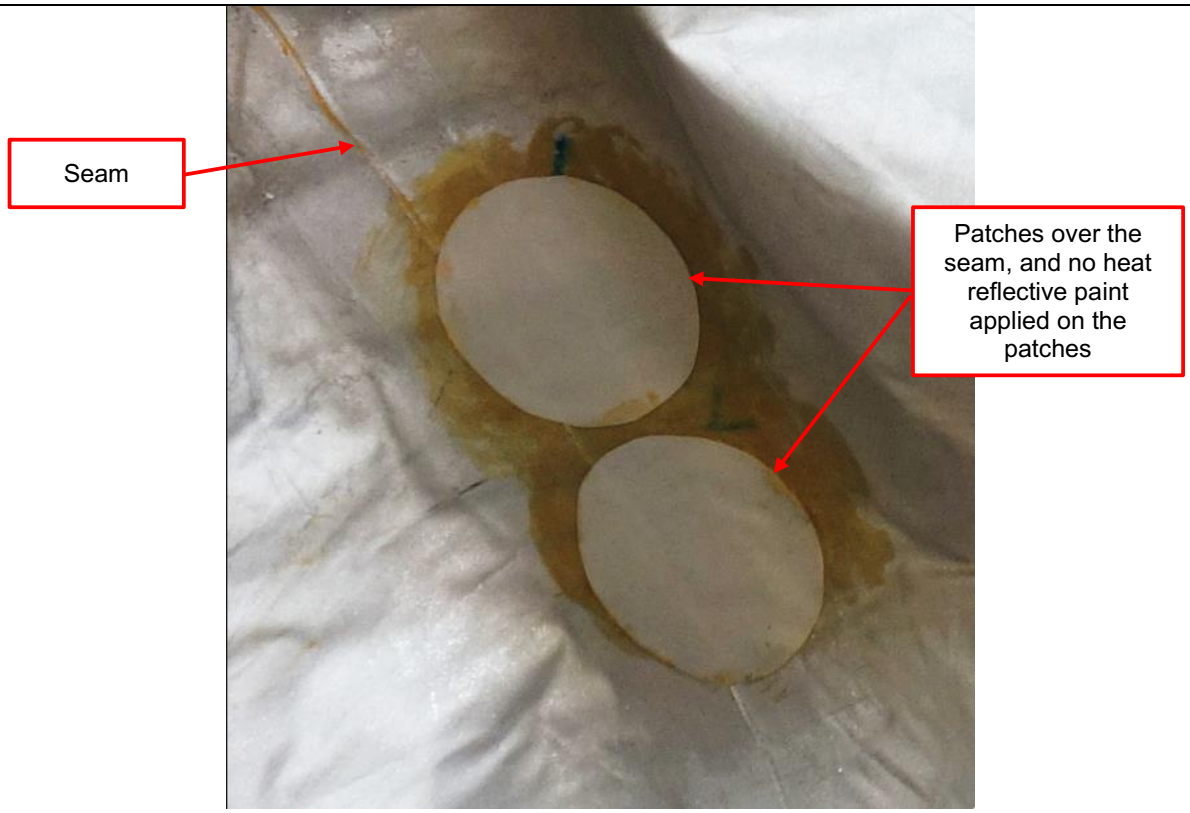

Figure 19B: Patches overlapping seam and no heat reflective paint is applied
(Picture was taken at Collins Phoenix facility)

4. Findings/Conclusions

A. FWD RH Door Slide (S/N BNG2562)

The cause for the inflatable deflation after the slide deployment is evident from the 59-inch long tear. The origin for the 59-inch long tear was not identified from the slide inspection findings. The separate punctured hole in the right-hand side of the inflatable tube was likely caused by the slide removal process which included the slide being dragged on the ground and over rocks. Slide inspection did identify additional non-conformances including improper secondary restraint installation, incorrectly routed girt cable, and incorrectly routed battery harness. Failure to connect the secondary restraint is critical packing error and could result in the slide failing to deploy as designed. This packing non-conformance may have contributed to the cause of the inflatable fabric tear by deploying in an unintended manner that exposed the slide to foreign object damage or excessive deployment forces.

The slide inflatable fabric did not show any signs of deterioration or weakness that would cause the fabric to tear during inflation. The slide inspection found no indication of entanglement during slide inflation that could cause excessive stress on the inflatable and cause the tear to occur.

The 5A3307 series slide can be used as a flotation device; however, it is not required to conduct testing in a ditching application (water landing evacuation) during development or qualification. It is possible that the combination of the packing non-conformances and the ditching application resulted in the slide experiencing foreign object damage (FOD) from the aircraft door, causing the identified tear on the inflatable tube.

B. FWD LH Door Slide (S/N BNG2056)

The root cause for the slide deployed in a twisted orientation was not identified during the investigation. The 5A3307 series slide can be used as a flotation device; however, it is not required to conduct testing in a ditching application (water landing evacuation) during development or qualification. Therefore, Collins can only provide some plausible causes for why the slide deployed in a twisted condition.

1. During a typical slide deployment, the slide drops from the aircraft door approximately 2 to 3 feet before firing cable become under tension, which pulls the cable from the regulator and starts the inflation system. Due to concerns raised by the other non-conformances identified, it is possible that the firing cable slack was not correctly maintained per the packing instructions. If the firing cable had less than the required amount of slack, the slide could begin to inflate early than intended. In the slide deployment sequence one corner of the packed slide begins to drop first as the door is opened. When the slide is correctly packed the unit fully clears the door and sill with the head-end aligned horizontally to the sill prior to the initiation of the inflation system. If the inflation system was initiated earlier in the sequence it is possible that the slide would not have had enough time to be aligned properly, causing it to inflate in a twisted condition. This condition could also occur if the door was not opened quickly enough or if the door was only partially opened, resulting in the slide deployment being intiated in a twisted condition.

2. The river water level is believed to be approximately 2 to 3 feet below the door sill at the time of the incident when the aircraft came to rest. However, the agitation of the river water (ex. waves) during the time of the slide deployment is unknown. The river water agitation could have turned the slide prior to completing the inflation, causing it to inflate abnormally.

5. Corrective Action/Recommendations

Due to the conditions and failure modes identified, there is no indication that the issues identified in the investigation would be present in other systems. Therefore, Collins recommends the following actions:

1. Collins recommends the service center to follow the applicable slide Components Maintenance Manual (CMM) carefully when performing repairs on the slide. Additionally, Collins recommends the service center to follow the applicable Packing Instruction (PI) carefully when packing the slide.

2. Collins recommends the aircraft operator to send the slide to Collins MRO network or a Collins trained third-party MRO for slide maintenance/overhaul. Third-party MRO facilities are required to use approved tooling and the latest up-to-date overhaul documents to service the Collins evacuation systems. There have been occurrences of maintenance/overhauls performed with superseded documentation and/or incorrect tool usage by unauthorized/untrained third-party MRO shops resulting in deployment complications.

3. Collins recommends that aircraft operators either verify the capability of the third party MRO shop or reach out to a Collins field representative for further assistance. More information can be found on Collins published SNL 25-259, Rev. Orig, Dated Apr 20-17.

[redacted] 8/29/2019

Pradeep Kurian
Evacuation Systems Product Support – Engineer

[redacted] 8/29/2019.

Kashyap Patel
Evacuation Systems Product Support – Sr. Supervisor

[redacted] 8/29/2019

Bruce Friedrich
Evacuation Systems – Sr. Project Engineer

[redacted] 8/29/2019

Eric Folland
Evacuation Systems – Engineering Supervisor

[redacted] 8/29/2019

Ray McBurnett, PE
Evacuation Systems – Chief Engineer

Appendix A

Supplementary Recommendations:

Emergency evacuation systems are complex in design and are safety-critical items. The operation of the emergency evacuation system relies on appropriate maintenance practice; in particular, the following should be followed when overhauling a slide:

- The correct slide overhaul as per applicable CMMs (latest issue),
- The correct slide packing as per applicable Packing Instruction (latest issue),
- The correct system installation & maintenance on aircraft as per applicable AMMs (latest issue).

Accordingly Collins recommends that operators and their maintenance organizations ensure that the following procedures are adhered to:

- All maintenance actions on evacuation systems are performed by authorized stations only.
- Each person performing maintenance actions on evacuation systems is properly trained and qualified.
- The required training is repeated on a regular basis.
- The latest versions of applicable CMMs and Packing Instructions are used for evacuation system overhaul and packing.
- All approved tools and fixtures are used per applicable CMMs and Packing Instructions.
- Data retrieved during maintenance actions must be recorded.
- The evacuation systems are installed and maintained on aircraft in accordance with the latest revision of applicable AMM sections.

Appendix B

UTC Aerospace Systems contact information

A. For parts and materials

Orders should be addressed to:

UTC Aerospace Systems - Interiors
3414 S. Fifth St.
Phoenix, AZ 85040-1169 USA

Contact Information:

Website: www.customers.utcaerospacesystems.com
Email: CSPPORTAL@hs.utc.com
Phone: +1 877-808-7575

B. For technical support, please contact:

Website: www.utascrc.com
Email: crc@utas.utc.com
US Toll Free Phone: +1 860-808-7575
Phone: +1 860-654-2500

C. For the latest technical publications, please visit the UTC Customer Portal:

Website: www.customers.utcaerospacesystems.com

Field Investigation Report

SUBJECT: Miami Air International, B737-81Q, Aft Slide Inflatable Rupture After Flat Fire Test

Report Date: 23-Sep-2019

CUSTOMER	AIRCRAFT	DOOR LOCATION	INCIDENT DATE	INCIDENT LOCATION
Miami Air International (MAI)	B737-81Q, N732MA, MSN 30618	Aft Right Hand	10-May-2019	Jacksonville Naval Air Station, Florida
ESCAPE SLIDE P/N	**ESCAPE SLIDE S/N**	**SLIDE DESCRIPTION**	**SLIDE DOM**	**LAST OVERHAUL**
5A3307-7	BNG1781	FWD & AFT Door Evacuation Slide, LH/RH	Jun-2000	American Southeast Inflatable & Oxygen

1. Description of Incident

On May 3rd 2019, Miami Air International (MAI) aircraft B737-81Q (MSN 30618, Registration N732MA) departed the end of the runway and came to rest in the shallow water of the St. Johns River as it landed at Jacksonville Naval Air Station, Jacksonville, Florida. Flight attendants proceeded with the emergency evacuation procedure and deployed the forward door emergency evacuation slides. The forward door emergency evacuation slide deployments were not successful, the investigation report for those slides is documented in FIR 19-4487. Flight attendants at the aft of the aircraft noticed water on the floor and determined it would be unsafe to open the aft doors during a water-landing (refer to Figure 1). The passengers including the crew evacuated safely via the overwing exits.

This incident investigation is led by the NTSB. After the incident, the aft door slides remained attached to the aircraft for approximately 1 week before the slides were extracted. After the slide extraction the investigation team performed a flat fire test of both aft door slides. Both slides inflated successfully (refer to Figure 2); however, the aft right-hand (AFT RH) inflatable ruptured approximately 5 minutes after the inflation.

Under NTSB supervision the AFT RH inflatable was shipped to Collins Aerospace in Phoenix, AZ, for further inspection and evaluation.

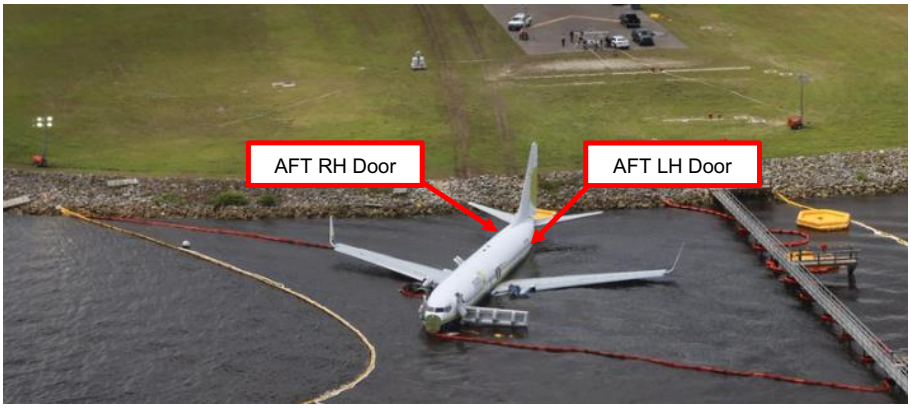

Figure 1. MAI B737 at Jacksonville Naval Air Station
(Photo extracted from CBS news video report)

Figure 2. AFT door location slides flat fire test
(Photo extracted from NTSB provided video)

References

Ref./1/: Miami Air International B737-81Q, N732MA
Ref./2/: Evacuation Slide (GA, AFT RH) P/N 7A1509-125, S/N BNG1781
Ref./3/: CMM 25-60-37 Vol.1 Rev. 10
Ref./4/: CMM 25-60-37 Vol.2 Rev. 02 (Packing Instructions, PI)

2. Background Information

A. Escape Slide Components:

Part Name	As Received		As Manufactured	
	P/N	S/N	P/N	S/N
737 Escape Slide	5A3307-7	BNG1781	5A3307-3	BNG1781
Inflatable Assembly	5A3305-101	BNG1781	5A3305-101	BNG1781

Table 1: Slide Components Particulars

B. Recent Overhaul History:

Inspection/ OVHL Date	OVHL Location	Incoming P/N	Outgoing P/N	Tasks Performed	Disposition	Comments
Jan-2019	American Southeast Inflatable & Oxygen	5A3307-7	5A3307-7	OVHL	Certified for in-service	OVERHAUL

Table 2: Recent Overhaul History

Maintenance History

The evacuation system P/N 5A3307-7, S/N BNG1781 was manufactured in June 2000 as evacuation system P/N 5A3307-3, S/N BNG1781. American Southeast Inflatable & Oxygen performed the last maintenance on January 2019 (refer Appendix A).

3. Examination

A. Investigation at Collins Aerospace in Phoenix

After the incident, the evacuation slide was sent to Collins Phoenix MRO for an investigation. The investigation team consisted of the following members:

Team members:

Emily Gibson Chaklos	NTSB - Survival Factors Investigator
Albert P. Nixon	NTSB - Regional Investigator
Peggy Jean Hurlbert	FAA - CSI
Bruce Wallace	Boeing - Evacuation Systems Engineering
Eric Folland	Collins Aerospace - Evac Systems Engineering Supervisor
Bruce Friedrich	Collins Aerospace - Evac Systems Sr. Project Engineer
Pradeep Kurian	Collins Aerospace - Evac Systems Product Support Engineer
AL Bale	Collins Aerospace - Evac System Product Safety Engineer
Nelson Gutierrez	Collins Aerospace - Evac System Trainer

The slide assembly was received at Collins MRO facility in a deployed condition (refer Figure 3).

Figure 3: AFT RH door inflatable receiving condition
(Picture was taken at Collins Phoenix facility)

The seam separation on the left side head end tube was the location of the rupture (refer Figure 4).

Figure 4: Seam separation head end tube left side
(Picture was taken at Collins Phoenix facility)

Several attachment patches including lifeline patches and mooring line patches had visible lifts and were not fully attached (refer Figure 5).

Figure 5: Inflatable patch lifts
(Picture was taken at Collins Phoenix facility)

Similarily, the twist correction panel on the right hand side of the inflatable was also found to not be fully attached to the tube structure (refer Figure 6).

Figure 6: Twist correction panel attachment
(Picture was taken at Collins Phoenix facility)

The seam separation of head end tube appears to be exhibiting an adhesive bond failure. To support further investigation, the slide was cut into sections. The following representative sections were tested to determine seam and attachment strength integrity from inflatable (refer Figure 7).

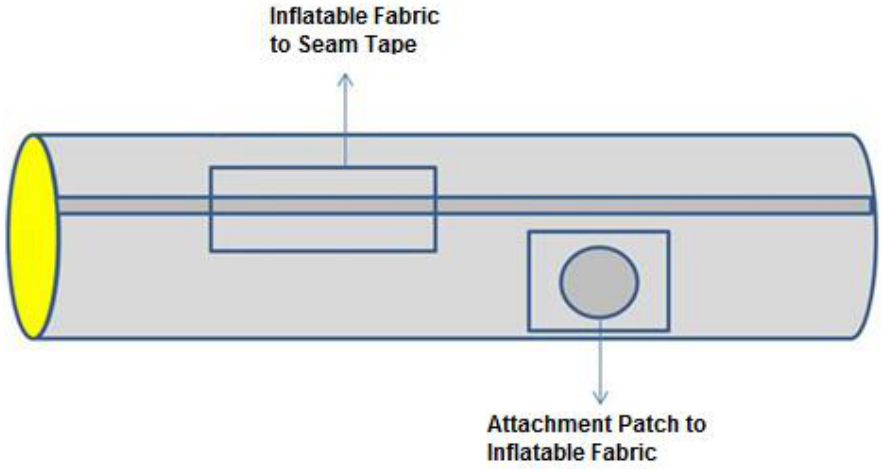

Figure 7: Inflatable Section Schematic

Seam peel adhesion strength testing is conducted on the seams where at the location of the rupture as well as seams located from other areas of the slide (BNG1781). Trapezoidal tear strength and grab tensile strength testing was also conducted on the fabric from both sides of the slide (refer Table 3).

Boeing 737 - S/N # BNG1781				
TEST	**MATERIAL**	**GOODRICH REQUIREMENT**	**AVG**	**Pass/ Fail**
Seam Peel Adhesion Strength	Butt Seam (Inflatable Fabric/Seam Tape) - Right Tube	≥9 lb./in	13.4	Pass
	Butt Seam (Inflatable Fabric/Seam Tape) - Left Tube		10.5	Pass
	Butt Seam (Inflatable Fabric/Seam Tape) - Adjacent to Failed Seam		3.6	Fail
	Attachment Fabric/Inflatable Fabric (partially failed)	≥6 lb./in	3.0	Fail
	Attachment Fabric/Inflatable Fabric (not failed)		5.2	Fail
	Attachment (Slide Lane/Inflatable Fabric)	≥7 lb./in	7.6	Pass

Table 3: BNG1781 (AFT RH) Inflatable Material Testing

In order to provide a comparison, the forward door slides (BNG2562 and BNG2056) from the same aircraft were also subjected to material level testing (refer Table 4 and Table 5).

Boeing 737 - S/N # BNG2562				
TEST	**MATERIAL**	**GOODRICH REQUIREMENT**	**AVG**	**Pass/ Fail**
Seam Peel Adhesion Strength	Butt Seam (Inflatable Fabric/Seam Tape)- Right Tube	≥9 lb./in	17.3	Pass
	Butt Seam (Inflatable Fabric/Seam Tape)- Left Tube		17.1	Pass
	Attachment Patches Fabric/Inflatable Fabric	≥6 lb./in	8.3	Pass
	Attachment (Slide Lane/Inflatable Fabric)	≥7 lb./in	8.1	Pass

Table 4: BNG2562 (FWD RH) Inflatable Material Testing

Boeing 737 - S/N # BNG2056				
TEST	**MATERIAL**	**GOODRICH REQUIREMENT**	**AVG**	**Pass/ Fail**
Seam Peel Adhesion Strength	Butt Seam (Inflatable Fabric/Seam Tape)- Right Tube	≥9 lb./in	13.7	Pass
	Butt Seam (Inflatable Fabric/Seam Tape)- Left Tube		10.9	Pass
	Attachment Patches Fabric/Inflatable Fabric	≥6 lb./in	12.8	Pass
	Attachment (Slide Lane/Inflatable Fabric)	≥7 lb./in	13.8	Pass

Table 5: BNG2056 (FWD LH) Inflatable Material Testing

Additionally, infrared spectroscopy was performed on BNG1781 (AFT RH). There were areas of clear and yellow adhesive on the material sample, both were analyzed (refer Figure 8). Results indicate that the areas have the same spectral characteristics, therefore both samples appear to be the same adhesive. Similar analysis on the fabric coating shows peaks in similar areas, which identifies that the adhesive chemistry is consistent with a urethane adhesive.

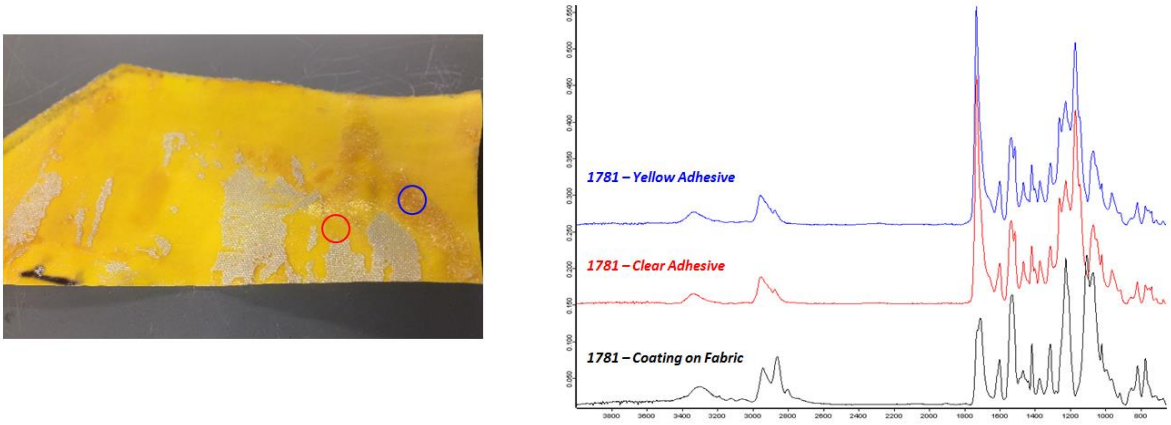

Figure 8: BNG1781 (AFT RH) Material Analysis

4. Findings/Conclusions

The aft right hand door slide showed clear signs of deteriorated seam bonds and attachments throughout the inflatable. The material test results showed the seam strength adjacent to the burst location was significantly below the specified requirement. However, the seam strength at other locations met the requirements. The attachment strength of the inflatable patches tested were also below the requirements. In comparison, the forward door slides met the seam peel requirement in the seam locations as well as the attachment bond strength.

The infrared spectroscopy that was performed on the aft right hand door slide did not identify any clear anomalies. The adhesive appears to be a urethane adhesive as designed, and no sign of contamination was found.

According to the provided FAA Form 8130-3 (refer Appendix A), this slide was last overhauled on January 2019. During a typical overhaul, the slide assembly will be visually inspected and put through proof pressure and air retention test per the applicable CMM. If a thorough visual inspection is performed, it is expected that the lifts as seen in Figures 5 and 6 would be identified and addressed. During a proof pressure test, slide is pressurized to 4.8 psig which is 1.5 times the expected maximum pressure that would be seen during typical slide inflation. Passing this test provides confidence that the slide would function as the design intends in the field when exposed to the maximum operating pressure of 3.2 psig.

The forward door slides (BNG2562, DOM Feb-2001, and BNG2056, DOM Sep-2000) present on the aircraft did not experience the same adhesive deterioration as found on the aft right hand unit. Therefore, it is unlikely that this deterioration occurred in the 5 months since the last overhaul and would have been present at last overhaul. If the overhaul is performed per the applicable CMM, it is expected that the seam deterioration and attachment lifts would be identified and addressed.

5. Corrective Action/Recommendations

Due to the conditions and failure modes identified, there is no indication that the issues identified in the investigation would be present in other systems. The slide is only expected to see pressures of 3.2 psig or lower in the field. The proof pressure test of 4.8 psig performed at overhaul is sufficient to provide a safety margin to expected field pressures. Therefore, Collins recommends the following actions:

1. Collins recommends the service center to follow the applicable slide Components Maintenance Manual (CMM) carefully when performing repairs on the slide. Additionally, Collins recommends the service center to follow the applicable Packing Instruction (PI) carefully when packing the slide.

2. Collins recommends the aircraft operator to send the slide to Collins MRO network or a Collins trained third-party MRO for slide maintenance/overhaul. Third-party MRO facilities are required to use approved tooling and the latest up-to-date overhaul documents to service the Collins evacuation systems. There have been occurrences of maintenance/overhauls performed with superseded documentation and/or incorrect tool usage by unauthorized/untrained third-party MRO shops resulting in deployment complications.

3. Collins recommends that aircraft operators either verify the capability of the third party MRO shop or reach out to a Collins field representative for further assistance. More information can be found on Collins published SNL 25-259, Rev. Orig, Dated Apr 20-17.

[redacted] 9/23/2019
Pradeep Kurian
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[redacted] 9/20/2019
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Eric Folland
Evacuation System – Engineering Supervisor

[redacted] 9/23/19
Ray McBurnett, PE
Evacuation System – Chief Engineer

Appendix A

1. Approving Civil Aviation Authority/Country:	2.	3. Form Tracking Number:
FAA/United States	**AUTHORIZED RELEASE CERTIFICATE** FAA Form 8130-3, AIRWORTHINESS APPROVAL TAG	**114721**

4. Organization Name and Address:	5. Work Order/Contract /Invoice Number:
American Southeast Inflatable & Oxygen & Oxygen, Inc. **FAA Repair Station YISR800L** **2891 NW 75th Street** **Miami, FL 33147** FAA Approval Holder: YISR800L	**R11456 / RO53332**

6. Item	7. Description:	8. Part Number:	9. Quantity:	10. Serial Number:	11. Status/Work:
1	Evacuation Slide W.B.	5A3307-7	1.00	BNG1781	OVERHAULED

12. REMARKS:

Overhauled IAW UTC Aerospace Systems CMM 25-60-37, Rev. # 8. Rev. Date: 05/16. S/B's & FAA AD's, If applicable complied with. Full details held in W.O.# R11456

Slide Mfg. Date:	06-2000	Slide Insp Due Date:	01-2020
Cyl. Assy. P/N:	4A3904-5	Batt P/N:	7-1045-201
Cyl. S/N:	IY22659	Batt. Exp. Date:	03-2023
Cyl. Mfg. Date:	11-2012	Cyl. Exp. Date:	11-2027
Cyl. Hydro Date:	01-2019	Next Hydro Due Date:	01-2024

American Southeast Inflatables and Oxygen certifies that the work specified in block 11/12 was carried out in accordance with EASA Part-145 and respect to that work the component is considered for release to service under EASA Part -145 approval: "EASA. 145.5088".

See other side for Work Performed.

13a. Certifies the items identified above were manufactured in conformity to:	14a. [X] 14 CFR 43.9 Return to Service [X] Other regulation specified in Block 12
☐ Approved design data and are in a condition for safe operation. ☐ Non-approved design data specified in Block 12	Certifies that unless otherwise specified in Block 12, the work identified in Block 11 and described in Block 12 was accomplished in accordance with Title 14, Code of Federal Regulations, part 43 and in respect to that work, the items are approved for return to service.

13b. Authorized Signature:	13c. Approval Authorization No:	14b. Authorized Signature: [redacted]	14c. Approval/Certificate No: YISR800L
13d. Name (Typed or Printed):	13e. Date (dd/mmm/yyyy):	14d. Name (Typed or Printed): Carlos A Mayer	14e. Date (dd/mmm/yyyy): 16/Jan/2019

User/Installer Responsibilities

It is important to understand that the existence of this document alone does not automatically constitute authority to install the aircraft engine/propeller/article.

Where the user/installer work in accordance with the national regulations of an airworthiness authority different than the airworthiness authority of the country specified in Block 1 it is essential that the user/installer ensures that his/her airworthiness authority accepts aircraft engine(s)/propeller(s)/article(s) from the airworthiness authority of the country specified in Block 1.

Statement in Blocks 13a and 14a do not constitute installation certification. In all cases aircraft maintenance records must contain an installation certification issued in accordance with the national regulations by the user/installer before the aircraft may be flown.

FAA Form 8130-3 (02-14) NSN:0052-00-012-9005

Appendix B

Supplementary Recommendations:

Emergency evacuation systems are complex in design and are safety-critical items. The operation of emergency evacuation systems relies on appropriate maintenance practice, in particular, the following should be followed when overhauling a slide:

- The correct slide overhaul as per applicable CMMs (latest issue),
- The correct slide packing as per applicable Packing Instruction (latest issue),
- The correct system installation & maintenance on aircraft as per applicable AMMs (latest issue).

Accordingly Collins recommends that operators and their maintenance organizations ensure that the following procedures are adhered to:

- All maintenance actions on evacuation systems are performed by authorized stations only.
- Each person performing maintenance actions on evacuation systems is properly trained and qualified.
- The required training is repeated on a regular basis.
- The latest versions of applicable CMMs and Packing Instructions are used for evacuation system overhaul and packing.
- All approved tools and fixtures are used per applicable CMMs and Packing Instructions.
- Data retrieved during maintenance actions must be recorded.
- The evacuation systems are installed and maintained on aircraft in accordance with the latest revision of applicable AMM sections.

Appendix C

UTC Aerospace Systems contact information

A. For parts and materials

Orders should be addressed to:

UTC Aerospace Systems - Interiors
3414 S. Fifth St.
Phoenix, AZ 85040-1169 USA

Contact Information:

Website: www.customers.utcaerospacesystems.com
Email: CSPPORTAL@hs.utc.com
Phone: +1 877-808-7575

B. For technical support, please contact:

Website: www.utascrc.com
Email: crc@utas.utc.com
US Toll Free Phone: +1 860-808-7575
Phone: +1 860-654-2500

C. For the latest technical publications, please visit the UTC Customer Portal:

Website: www.customers.utcaerospacesystems.com